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DRYING OF SEED COTTON AT GINS

By Francis L. Gerdes, Senior Cotton Technologist,
Ralph A. Rusca, Junior Cotton Technologist,
Agricultural Marketing Service,

and

Victor L. Stedronsky, Mechanical Engineer,
Bureau of Agricultural Chemistry and Engineering

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THE COTTON DRYING MOVEMENT AND SOME PROBLEMS CONNECTED WITH IT

The artificial drying of seed cotton at commercial gins is a comparatively new development in the cotton industry. The first successful mechanical driers made their appearance in cotton gins in the late twenties. The Department of Agriculture began to study methods and equipment for artificially drying seed cotton in 1926 and 4 years later established the U. S. Cotton Ginning Laboratory at Stoneville, Miss., with facilities for testing cotton quality in order to investigate thoroughly the drying and ginning problems. Soon thereafter the laboratory developed and tested the vertical drier for seed cotton. Several commercial ginners built and installed this type of drier in 1931 and found it satisfactory. Manufacturers of ginning machinery also made vertical driers and began to develop other types about this time.

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[1] The 3-year study upon which this report is based was made possible through the cooperation of operators of drier-equipped gins, manufacturers of cotton driers, and State agricultural extension specialists doing gin extension work in the Cotton Belt. The manufacturers provided up-to-date lists of drier-equipped gins, the gin operators furnished data on their drying operations, and the State specialists assisted in collecting some of the data the first year of the study. Reports were made by 56 percent of all the drier operators in 1938, and by 42 percent in each of the 2 succeeding years.

In 1931 only about 15 gins, drying about 30,000 bales of cotton, were equipped with driers. Driers became so popular that the number of commercial installations increased to 200 in 1935, and the number of new installations since that time has been increasing rapidly. By 1940 1,340 gins were using driers as standard equipment for conditioning and cleaning seed cotton and improving the grade of the ginned lint.

The rapidly increasing number of installations and the widespread use of driers under the varied conditions prevailing throughout the Cotton Belt have brought to those who use them many problems in connection with operating practices. The U. S. Cotton Ginning Laboratory has been carefully appraising the results of the drier movement in the field since this mechanical device began to assume importance as a factor affecting the quality and the value of the American cotton crop. As its influence became noticeable, unconfirmed reports began to come to the Department to the effect that some cotton mills were making complaints to the shippers concerning the quality of dried cotton. It was alleged that drying at too high a temperature caused unfavorable spinning results. Therefore, the laboratory in 1938 intensified its efforts to discourage such faulty methods of operation, and took steps to obtain more comprehensive data on the results of these practices as well as to obtain information on operating practices, benefits, disadvantages, and costs.

In addition to making periodic inspections of drying activities in the field to ascertain whether or not the experimental results were being reproduced under commercial conditions, the laboratory obtained, through interviews and by mail, information direct from drier users regarding their drying operations. This 3-year study was completed in 1940. It is the purpose of this publication to present a summary of the results obtained, together with related information, so that those concerned may have the benefit of the experiences of drier operators, and results of recent experimental work.

RESULTS OF LABORATORY TESTS OF COTTON DRIERS

In laboratory tests, it was found that drying green, damp, or wet cotton increases the market value of the ginned lint as much as \$2.50 per bale for long staple cotton. This results because of the smoother ginning and higher grade associated with reduction of the moisture content of the cotton at time of ginning. Staple length, on the average, was preserved when the cotton was dried at 150° F., but higher drying temperatures sometimes resulted in ginned lint with slightly shorter staple length. In many cases, drying temperatures above 200° F. were associated with shortening the staple by 1/32 to 1/16 of an inch. Fiber strength was not weakened by drying the seed cottons at temperatures up to 200° F., but repeated passage of the cotton through the drier at high temperatures resulted in a weakening of the fibers.

Spinning tests 2/ made in the Department's spinning laboratories over a period of years on undried and dried cottons have shown that temperatures above 200° F. definitely resulted in weaker yarns; but when the recommended temperature of not more than 160° F. was used in drying, the studies have shown that the grade of the cotton was definitely improved without a significant loss in strength of the yarn 3/. In tests with 8 different cottons, aliquot portions of each of which respectively were ginned in a green and damp condition and after having been dried at various temperatures up to and including 190° F., the dried cotton produced yarns that were only 1 percent weaker than those spun from the undried cotton. Such a decrease would be negligible from any practical standpoint in the processing of cotton. The benefits from drying were reflected in lower waste removed by the picker and carding machinery; and the difference in waste removal was about as much as the average difference between Middling and Strict Middling cotton.

Results of a recently completed 2-year study of seed in storage showed that the artificial drying of green, damp, or wet cotton at gins has no lasting effect on seed temperature or moisture content, but that it slightly increases germinative properties and retards the development of free fatty acid 4/.

TYPES OF DRIERS IN USE

In addition to the vertical tower drier extensively used in the Cotton Belt several other designs are widely employed. These include the unit extractor-cleaner-feeder system, the multiple conveyor-distributor drier, the vertical tower and spiked-drum cleaner-drier, the ribbon-conveyor cleaner-drier, the paddle-wheel-drum cleaner-drier, and the multiple-cylinder axial-flow air-line drier (fig. 1). Various combinations of these drying units are sometimes employed to obtain increased exposure of the cotton to hot air and effective drying at low temperatures.

REGIONAL DISTRIBUTION OF DRIER-EQUIPPED GINS

The rate of installation of cotton driers in the Cotton Belt since 1931 has been influenced by the intensity of the seed cotton moisture problem in the

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2/ These spinning tests were conducted at the Department's spinning laboratory at Clemson, S. C., under the supervision of M. E. Campbell, Senior Cotton Technologist, Agricultural Marketing Service.

3/ Campbell, Malcolm E., Some spinning test results of interest to cotton manufacturers. Agr. Mktg. Serv., June 1940 (Mimeographed.)

4/ Rusca, Ralph A., and Gerdes, Francis L., Effects of artificially drying seed cotton on certain quality elements of cottonseed in storage. U.S. Dept. Agr., Agr. Mktg. Serv. (In process of preparation for publication.)

different regions as well as the volume of ginning (fig. 2). The first several years after the cotton drier was placed on the market found most of the driers installed in areas adjacent to the Mississippi River and along the Gulf Coast of Texas (tables 1 and 2). This situation, however, has changed in the last 3 or 4 years, as ginners in all States have found it necessary or to their advantage to use driers. The largest percentage of active gins so equipped is still in the Mississippi Valley or Central States, partly because of the humid conditions prevailing in that region and partly because ginning methods there seem to be more up to date than in some of the other sections.

Table 1.--Number of cotton gins in the United States equipped with driers, 1935-40

State and group of States	Gins equipped with driers					
	1935	1936	1937	1938	1939	1940
	Number	Number	Number	Number	Number	Number
Alabama	14	14	23	38	66	83
Florida	0	0	0	1	3	3
Georgia	6	6	13	17	32	59
North Carolina	6	8	17	19	21	32
South Carolina	4	10	31	41	57	72
Virginia	1	1	1	1	1	1
Southeastern States	31	39	85	117	180	250
Arkansas	30	37	69	86	121	156
Illinois	0	0	0	0	2	2
Kentucky	2	2	3	3	4	4
Louisiana	23	36	72	124	166	181
Mississippi	26	44	101	144	182	223
Missouri	17	23	45	62	96	128
Tennessee	2	3	6	9	21	29
Central States	100	145	296	428	592	723
Arizona	1	1	2	6	9	11
California	12	23	40	46	48	56
New Mexico	0	0	0	3	3	8
Oklahoma	6	7	8	9	10	22
Texas	50	66	131	199	231	270
Southwestern States	69	97	181	263	301	367
All States	200	281	562	808	1,073	1,340

Data based on survey by the Agricultural Marketing Service, of cotton gins equipped with cotton driers.

Table 2.--Percentage of cotton gins in the United States equipped with driers, 1935-40

State and group of States	Gins equipped with driers					
	1935	1936	1937	1938	1939	1940
	Percent	Percent	Percent	Percent	Percent	Percent
Alabama	1.1	1.1	1.9	3.1	5.7	7.4
Florida	0.0	0.0	0.0	2.1	7.3	8.1
Georgia	0.4	0.4	0.9	1.3	2.5	4.8
North Carolina	0.6	0.8	1.8	2.2	2.6	3.9
South Carolina	0.4	0.9	2.9	4.2	6.1	8.2
Virginia	1.1	1.2	1.2	1.4	1.7	1.7
Southeastern States	0.6	0.8	1.8	2.6	4.2	6.0
Arkansas	2.7	3.2	5.9	7.5	10.6	13.7
Illinois	0.0	0.0	0.0	0.0	66.7	66.7
Kentucky	22.2	20.0	30.0	27.3	36.4	36.4
Louisiana	3.6	5.6	10.9	19.3	26.5	29.8
Mississippi	2.0	3.3	7.4	10.7	13.8	17.4
Missouri	11.3	14.6	26.2	37.1	56.8	69.6
Tennessee	0.5	0.7	1.4	2.1	5.0	6.9
Central States	2.7	3.9	7.8	11.4	16.0	19.8
Arizona	2.2	2.1	3.6	11.1	17.6	20.4
California	16.9	27.1	38.1	46.0	48.0	55.4
New Mexico	0.0	0.0	0.0	7.0	7.1	19.5
Oklahoma	0.7	1.0	1.1	1.3	1.5	3.3
Texas	1.5	2.0	4.0	6.3	7.6	9.0
Southwestern States	1.6	2.3	4.3	6.5	7.7	9.5
All States	1.6	2.2	4.4	6.6	9.0	11.5

Data based on survey by the Agricultural Marketing Service, of cotton gins equipped with cotton driers.

It is noteworthy that the number of driers in arid regions such as Oklahoma, New Mexico, and west Texas has about doubled during the last 2 years. Under conditions of this kind it has been found that the ginners ordinarily operate the driers with low heat and use them as cleaners, at the same time having additional heat always available to increase the drying action immediately when bales of green or damp cotton are encountered.

The number of driers in use has increased from 1 drier per 64 active gins in 1935 to 1 drier per 9 active gins in 1940, an increase of 670 percent in driers over the 5-year period (fig. 3). About 20 percent of the gins in the Mississippi Valley States were equipped with driers in 1940 as compared with 6 percent for the Southeastern States and almost 10 percent for the Southwestern States. Missouri, with over two-thirds of its gins equipped with driers, showed the greatest proportion of drier-equipped gins for the cotton-producing States. California was next, with more than one-half of its gins using driers. South Carolina, with 8 percent of its gins employing driers in 1940, had the highest proportion of gins so equipped in the Southeastern States, and the indications are that the number of drier installations in South Carolina and neighboring States is increasing rapidly.

GIN MACHINERY IN DRIER-EQUIPPED GINS

There is a tendency for the more modern gins to be equipped with driers. Based on surveys made throughout the Cotton Belt, the percentages shown in table 3 indicate that gins with driers tend to have more stands per outfit than do gins without driers; that they are equipped with more elaborate cleaning devices, and that they use extractor-cleaner-feeders to a greater extent and big drum and small drum feeders to a lesser extent. In the Southeast, driers are especially associated with larger-sized gins and with more extensive use of overhead cleaners and unit extractor-feeders. In the Southwest, most gins have elaborate overhead cleaning systems but frequently it is the practice to by-pass these units on cotton relatively free of foreign matter and to depend upon the drier in the dual function of cleaner and conditioner. Unit extractor-cleaner-feeders usually complete the cleaning set-up in these instances, but in some instances the larger-sized extractor-cleaner-feeders are used exclusively in lieu of overhead cleaning and extracting machinery in this area.

VOLUME OF COTTON DRIED

A comparison of data showing percentages of cotton handled per gin indicates that the larger and more modern gins are being equipped with cotton driers. In 1938 approximately 6.6 percent of the active gins were drier-equipped and these gins conditioned 8.4 percent of the total crop. In 1940, 11.5 percent of the gins with driers conditioned 14.2 percent of the crop (table 4). In other words, the average drier-equipped gin processed more cotton than the average gin without a drier.

The gins equipped with driers are doing an increasing volume of business each year. For both 1939 and 1940, greater increases are shown in the percentage of the total crop dried than in the increases in the percentage of gins equipped with driers. This could be an indication that the farmers prefer to have their cotton handled by gins equipped with driers, and, therefore, send more of it to gins so equipped.

It is natural that, since a larger proportion of the gins in the Central States are equipped with driers, a larger proportion of the crop in this area than in any other area would be processed through driers. In 1940, 29 percent of the green, damp, or wet cotton and 19 percent of the dry cotton were conditioned at the gins in this region to provide smoother and cleaner ginning with moist cotton and greater trash removal with the dry cotton. During this

Table 3.--Percentage of all gins 1/ and of drier-equipped gins 2/ having specified machinery, by States, season 1940

State and group of States	4 or more gin stands		Cleaners				Feeders					
			Overhead cleaner		Master extractor		Plain		Big drum		Unit-ext.-cleaner	
	All gins	Drier-equipped gins	All gins	Drier-equipped gins	All gins	Drier-equipped gins	All gins	Drier-equipped gins	All gins	Drier-equipped gins	All gins	Drier-equipped gins
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Alabama	42	84	26	68	5	32	30	3	28	21	42	76
Florida	28	-	14	-	0	-	38	-	22	-	40	-
Georgia	41	74	26	70	0	30	34	14	26	18	40	68
North Carolina	25	75	30	62	0	25	32	29	25	0	43	71
South Carolina	23	61	12	76	0	36	34	9	19	18	47	73
Southeastern States	33	73	24	70	2	32	32	11	25	17	43	72
Arkansas	44	69	66	79	16	35	14	2	19	13	67	85
Louisiana	45	65	67	59	0	14	20	4	23	35	57	61
Mississippi	45	66	36	54	7	14	17	3	23	17	60	80
Missouri	52	59	74	82	0	32	3	6	1	9	96	85
Tennessee	34	40	28	60	4	20	15	0	18	13	67	87
Central States	43	63	47	66	6	22	16	3	20	18	64	79
Arizona	96	84	89	60	66	0	35	25	19	0	46	75
California	97	100	-	100	-	48	16	15	35	50	49	35
New Mexico	91	100	100	67	0	33	18	0	7	0	75	100
Oklahoma	89	83	91	83	60	50	11	9	31	36	58	55
Texas	86	99	100	94	57	46	15	4	26	18	59	78
Southwestern States	88	97	95	93	61	45	15	7	27	26	58	67
All States	54	75	52	74	18	31	21	6	24	20	55	74

1/ Data based on 1940 cotton ginning machinery and equipment reports, Bureau of the Census.

2/ Data based on survey by Agricultural Marketing Service, of cotton gins equipped with cotton driers.

Table 4.--Percentage of total crop of cotton processed by driers, seasons 1938-40

Region	Crop year	Bales of specified moisture condition passed through the driers			Gins equipped with driers
		Green, damp, or wet bales	Dry bales	All bales	
		Percent	Percent	Percent	Percent
Southeastern	1938	5.6	4.6	5.0	2.7
	1939	6.8	4.0	5.3	4.1
	1940	11.0	6.4	8.5	6.0
Central	1938	17.0	10.2	12.6	11.4
	1939	25.1	14.1	19.0	16.2
	1940	29.0	19.2	24.4	19.8
Southwestern	1938	8.2	4.8	6.6	6.5
	1939	8.8	6.5	7.7	7.7
	1940	12.8	5.6	9.8	9.5
All	1938	11.2	6.7	8.4	6.6
	1939	14.8	8.7	11.5	9.0
	1940	17.7	10.4	14.2	11.5

Data based on survey by the Agricultural Marketing Service, of cotton gins equipped with cotton driers.

same period, the proportion of cotton in the Mississippi Valley so conditioned was almost three times that of the cotton conditioned in the other two areas.

In 1938, 8.4 percent of the United States cotton crop, or one million bales, was handled by driers, according to estimates based on the data obtained through the survey. The proportion of the crop dried increased to 11.5 percent, or 1.4 million bales, in 1939, and to 14.2 percent, or 1.8 million bales, in 1940. The 3-year average was 1.4 million bales.

For the Cotton Belt as a whole, the proportion of the ginnings made up of cotton dried with heat was about the same for 1938 and 1939, or about 60 percent, but it increased to 67 percent in 1940 (table 5).

Table 5.--Percentage of bales of specified moisture condition passed through the drying equipment, seasons 1938-40

Region	Crop year	Bales passed through the drying equipment: Green, damp, or wet bales: With heat	Green, damp, or wet bales: Without heat	Dry bales: With heat	Dry bales: Without heat	All bales: With heat	All bales: Without heat	Bales by-passed the drier
		Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Southeastern	1938	36	1	40	15	76	16	8
	1939	40	2	27	20	67	22	11
	1940	46	1	29	22	75	23	2
Central	1938	31	1	36	22	67	23	10
	1939	38	1	28	22	66	23	11
	1940	50	2	28	14	78	16	6
Southwestern	1938	29	1	11	17	40	18	42
	1939	25	1	18	10	43	11	46
	1940	40	1	11	15	51	16	33
All	1938	31	1	29	20	60	21	19
	1939	35	1	24	18	59	19	22
	1940	45	1	22	16	67	17	16

Data based on survey by the Agricultural Marketing Service, of cotton gins equipped with cotton driers.

The weather during the 1940 harvesting season was more rainy than during the 2 previous years, and therefore accounted to some extent for the increased use of cotton driers (table 6). The rainfall during the harvesting season in the Southwestern States for each of the 3 years was substantially less than that which occurred in the other areas, and consequently the proportion of the incoming cotton at the drier-equipped gins which had to be conditioned was correspondingly less. The average was slightly over two-fifths of the cotton for the Southwest as compared with almost three-fourths of the cotton for each of the other two areas (table 5).

Table 6.--Average rainfall and number of days with rain during the harvesting months, seasons 1938-40 1/

Region	Average rainfall			Days with rainfall 0.01 inch or more		
	1938	1939	1940	1938	1939	1940
	In.	In.	In.	No.	No.	No.
Southeastern	11.8	13.9	14.8	27	29	29
Central	11.4	9.8	14.8	22	23	27
Southwestern	4.8	5.8	8.7	13	17	22
All	9.3	9.8	12.8	21	23	27

1/ Calculated from monthly climatological reports of individual States by U. S. Weather Bureau. Harvesting season includes August, September, October, and November.

The percentage of green, damp, or wet bales conditioned by the drier-equipped gins increased from 31 percent in 1938 to 35 percent in 1939 and 45 percent in 1940. The percentage of wet bales not dried remained stationary at 1 percent. The percentage of dry bales exposed to heat decreased each year and those bales that passed through driers only for cleaning also decreased slightly.

As previously mentioned, seasonal weather conditions may be responsible for part of the increase in damp cotton received at the gins over the 3-year period of study, but there is another aspect of the study that should be discussed in this connection. The rapid advancement of the cotton drier as an integral part of the ginning system has, in some instances, found the farmers uninformed as to the true function of the drier. The ginners may be faced with the problem of persuading their customers to realize that driers have limitations. Driers were designed primarily for improving the grade of green and damp cotton and their use should not be abused. It should be emphasized that cotton cannot be harvested in an excessively wet and trashy condition with the expectation that artificial conditioning methods will completely restore the the grade to a point equal to that of cotton harvested in a normal, dry condition. The care with which cotton is harvested and handled, whether it is to be dried at the gin or not, is still of paramount importance.

DRYING AIR TEMPERATURES

Results from the 1938 survey indicated that drying temperatures in some sections were excessive, particularly in the Southwest (table 7). The average temperature used on wet cotton for all States was 192° F. in 1938, 23 percent of the gins employing heat above 200° F. (fig. 4). The average temperature for green and damp cotton was 175°, 13 percent of the driers being operated with temperatures above 200°. The average for dry cotton was 153°, only 2 percent of the driers employing temperatures in excess of 200° F. However, 20 percent of the drier-equipped gins operated in 1938 with temperatures on dry cotton above 175° F.

There was a slight reduction in average temperature and number of gins employing excessive heat in 1939 as compared with 1938, especially in the Southwestern States and the Central States. In the Southeastern area, where the increase in rainfall and the amount of moist cotton from 1938 to 1940 was greater than in other areas, the drying temperatures used did not change much from one year to the other. In 1940, the average temperature in all areas was higher than in the previous year. This was undoubtedly caused by the increased proportion of green, damp, or wet cotton resulting from the increased rainfall during the harvesting season of 1940 over 1939. The average drying temperatures used in 1940 at all cotton gins reporting in the Cotton Belt were 198° F. on wet cotton, 178° on green and damp cotton, and 154° on dry cotton.

It is apparent that some operators are employing drying air temperatures that are, in relation to the moisture content of the cotton, too high to preserve the staple length. The drying temperature generally should not exceed 160° F. for the usual run of green and damp cotton. A slightly higher temperature can be used with very wet cotton, but under no circumstances should it exceed 200°. The artificial drying process is not designed to dry wet cotton completely. High temperature "bakes" the cotton, reduces the fiber strength, and injures the spinning quality. It is preferable to pass wet cotton twice through a drier operated at moderate temperature rather than once at high temperature. Repeated passage of dried cotton from the gin overflow is objectionable, however. Attention must be given to the temperature element of drier operation if the most satisfactory results are to be obtained.

SOURCE OF HEAT FOR DRIERS

Heat for cotton driers is usually derived from one of three sources: Steam, furnaces, and waste heat from internal combustion engines 5/. With the latter it is usually necessary to supplement the recovered waste heat with heat from some other source in order to attain the higher temperatures sometimes needed in drying wet cotton (fig. 5).

5/Bennett, Charles A., Stedronsky, V. L., and Martin, William J., Sources of heat for drying seed cotton. U. S. Dept. Agri. Misc. Pub. No. 385, 22 pp., illus.

Table 7.--Average drying temperature used and number of driers operating in each temperature range, seasons 1938-40

Crop year	Condition of cotton	Average drying temp.	Driers operating in each temperature range				
			No heat	Below 150° F.	150° to 175° F.	176° to 200° F.	201° F. and above
		Deg. F.	Percent	Percent	Percent	Percent	Percent
			Southeastern Region				
1938	Wet	189	0	8	10	73	9
	Damp	178	0	8	27	59	6
	Dry	157	17	21	41	21	0
1939	Wet	188	0	5	14	65	16
	Damp	174	0	10	32	50	8
	Dry	152	10	28	38	19	5
1940	Wet	192	0	3	23	51	22
	Damp	181	0	7	36	44	13
	Dry	155	19	31	26	20	4
			Central Region				
1938	Wet	190	5	6	16	51	22
	Damp	175	4	13	33	36	14
	Dry	153	18	34	29	17	2
1939	Wet	185	0	10	27	46	17
	Damp	169	0	19	44	28	9
	Dry	139	20	47	25	6	2
1940	Wet	196	0	6	18	50	26
	Damp	179	0	12	36	38	14
	Dry	154	17	33	28	18	4
			Southwestern Region				
1938	Wet	198	0	7	14	46	33
	Damp	175	0	15	37	31	17
	Dry	160	22	26	27	19	6
1939	Wet	187	0	10	20	53	17
	Damp	165	0	21	40	33	6
	Dry	151	32	28	27	10	3
1940	Wet	203	0	7	11	46	35
	Damp	177	1	24	28	30	19
	Dry	157	39	21	26	8	6
			All Regions				
1938	Wet	192	3	7	15	52	23
	Damp	175	3	13	33	38	13
	Dry	153	10	21	31	18	2
1939	Wet	185	0	9	21	51	19
	Damp	171	0	18	39	34	9
	Dry	147	21	40	26	10	3
1940	Wet	198	0	6	17	49	28
	Damp	178	0	15	33	36	16
	Dry	154	23	29	27	16	4

Data based on survey by the Agricultural Marketing Service, of cotton gins equipped with cotton driers.

Most of the cotton driers utilize steam as the source of heat (table 8). The data reveal that the Southeastern States, in particular, make extensive use of steam boilers, while the Southwestern States use furnaces more generally.

Table 8.--Percentage of gins using specified source of heat for drying cotton, seasons 1938-40

Region	Crop year	Gins using specified source of heat		
		Steam heat	Furnace heat	Engine waste heat
		Percent	Percent	Percent
Southeastern	1938	92	3	6
	1939	97	2	1
	1940	93	6	1
Central	1938	74	17	9
	1939	65	23	12
	1940	56	38	6
Southwestern	1938	65	35	0
	1939	70	30	0
	1940	64	36	0
All	1938	74	19	7
	1939	74	20	6
	1940	65	31	4

Data based on survey by Agricultural Marketing Service, of cotton gins equipped with cotton driers.

The general trend is toward furnaces because they are more economical, the cost of drying by this means averaging about 13 cents per bale as compared with 16 cents by steam. They have the additional advantage of requiring less time between firing up and using the heater than is the case with steam boiler installations. The percentage of gins using boilers as a source of heat decreased from 74 to 65 percent and those employing furnaces increased from 19 to 31 percent from 1938 to 1940. The proportion of gins using heat exchangers has decreased slightly. In 1940, about two-thirds of the drier-equipped gins used steam as a source of heat; three-tenths, furnaces; and the remainder, heat exchangers.

FUEL USED IN PROVIDING HEAT FOR DRIERS

The type of fuel burned to provide heat for steam boiler outfits has remained fairly constant. Over one-half of the boilers were fired with coal for the 3 years 1938-40 (table 9). When either coal or wood is burned, the hulls cleaned from the seed cotton are often advantageously disposed of as supplementary fuel.

Table 9.--Percentage of gins using specified type of fuel for each source of heat, seasons 1938-40

Type of fuel	Steam heat			Furnace heat			Engine waste heat		
	1938	1939	1940	1938	1939	1940	1938	1939	1940
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Coal	50	51	52	2	1	3	4	25	0
Oil	25	30	23	22	22	16	88	42	74
Gas	12	9	14	75	77	81	8	33	26
Wood	11	10	11	0	0	0	0	0	0

Data based on survey by Agricultural Marketing Service, of cotton gins equipped with cotton driers.

The use of gas increased from 75 to 81 percent in 1940 over 1938 as the type of fuel for furnaces, and oil declined from 22 to 16 percent. This was perhaps caused by the rapidly expanding number of rural communities being supplied with natural gas or butane service, together with the fact that gas is a cleaner and more easily handled fuel, and is more adapted to intermittent use because it is immediately available.

FUEL EXPENSE IN DRYING

By Sources of Heat

The weighted average fuel cost per bale for drying was relatively stable from area to area and over the 3-year period, with the possible exception of the cost in the Southwest in 1938 when it was much higher than in succeeding years and much higher than in other areas in 1938 (table 10).

The 3-year weighted average fuel cost for steam heat in the Cotton Belt was 16 cents, and that for furnace was 13 cents, as compared with a 6-cent average for engine waste heat.

Table 10.--Fuel cost per bale for drying with specified source of heat, seasons 1938-40

Region	Crop year	Fuel cost per bale for specified source of heat: Steam heat	Furnace heat	Engine waste heat
		Cents	Cents	Cents
Southeastern	1938	15	10	5
	1939	16	14	3
	1940	16	6	20
Central	1938	15	12	5
	1939	15	10	7
	1940	15	14	7
Southwestern	1938	23	20	-
	1939	14	12	-
	1940	14	11	-
All	1938	16	14	5
	1939	16	11	7
	1940	15	13	8

Data based on survey by Agricultural Marketing Service, of cotton gins equipped with cotton driers.

By Drying Air Temperatures

A further analysis of the data on fuel expenses reported in the 3-year study indicates that the average cost for fuel for all sources of heat is 14 cents per bale for temperatures below 160° F., 15 cents for temperatures between 160° and 190°, and 16 cents for temperatures exceeding 190° F. It is to be expected that fuel consumption would be greater to maintain a temperature of 200° than a temperature of 150°, just as an automobile consumes more gasoline per mile driven at 70 than it does at 30 miles per hour.

By Ginning Volume

It is also natural to expect the cost of the fuel used to vary with the volume of cotton ginned. If the volume of business is such that the drier is not operated continuously, then the intermittent firing of the boiler or heating of the furnace will tend to use more fuel and consequently to increase operating costs.

A study of cost figures throughout the three seasons shows that fuel cost per bale varies inversely with the volume of cotton dried, as brought out in figure 6. The average cost of fuel per bale for drying less than 100 bales is almost 18 cents, and it gradually decreases to less than 10 cents per bale for 5,000 bales. The maximum number of bales reported as being dried by an individual gin was 5,300. Relatively few gins, however, processed more than 4,000 bales.

BENEFITS ASSOCIATED WITH DRYING COTTON AT GINS

Out of the 1,477 drier reports received from ginners during the 3-year period of the study, 1,196 reports, or 81 percent, indicated that the drier improved the grade of green, damp, or wet cotton; and 650 reports, or 44 percent, that it improved dry cotton, presumably through its cleaning action. Less than 4 percent of the reports stated that the drier was harmful to staple length, and the predominating reason given in these reports was excessive heat relative to the moisture content of the cotton. More than 500, or 35 percent, of the drier operators who reported volunteered favorable comments on the drier such as (1) "Driers are essential for good ginning;" (2) "Driers prevent chokages;" (3) "Driers are a valuable addition to the gin;" (4) "Driers are very satisfactory", etc. Only 12 operators made unfavorable comments on the drier.

Increases in Bale Value

Confirming the results of laboratory tests, bale value increases for wet and dry cottons, as established by the ginners under actual operating conditions, definitely show the advantage of artificially drying seed cotton. The average gain in value per bale for the 3 years, based on reports from the ginners, was about $4.50 on green, damp, or wet cotton and over $1 on dry cotton (table 11). According to the ginners, these gains in values are due principally to grade improvements resulting from drying and cleaning green, damp, or wet cotton, and from cleaning dry cotton.

Table 11.--Average increase in bale value as a result of drying, seasons 1938-40

Region	Crop year	Bale value increase for specified moisture condition	
		Green, damp, or wet bales	Dry bales
		Dollars	Dollars
Southeastern	1938	5.01	1.33
	1939	4.79	1.44
	1940	4.76	1.08
Central	1938	5.34	1.38
	1939	4.29	1.44
	1940	4.42	1.30
Southwestern	1938	3.72	1.03
	1939	3.66	1.10
	1940	3.48	1.43
All	1938	4.90	1.28
	1939	4.37	1.29
	1940	4.19	1.28

Data based on survey by Agricultural Marketing Service, of gins equipped with cotton driers.

Monetary benefits associated with drying have remained fairly constant from 1938 to 1940, especially on cotton of low-moisture content. The Southeastern and Central States, with their relatively humid weather conditions, reported the greatest benefits, while the Southwest, with its drier climate, indicated lesser ones.

It is important to note that benefits in 1940 are the lowest of any for the 3 years. This was to be expected because of the use of drying temperatures higher than those of the previous 2 years. This tends to substantiate laboratory findings to the effect that maximum bale value increases accrue when moderate heat is used in drying. It is unnecessary and generally harmful to use excessive temperatures.

Increases in Ginning Capacity

The ginners consistently reported that improved ginning capacity is associated with the drying of cotton at gins, especially of green, damp, or wet cotton. During the 3-year period of study, the reports showed average ginning capacity increases of 25 percent on moist cotton and 4 percent on dry cotton as a result of handling the seed cotton through the conditioning and drying units (table 12).

In general, increases in gin capacity associated with drying do not vary a great deal. Even though the three groups of States differ widely in climatic and harvesting conditions, the average capacity increase was reported to be practically the same for all the groups.

Ginners say this additional one-fourth capacity results from fewer chokages and breakdowns that so often occur when handling damp or wet seed cotton and because the drier permits a reasonable increase in the rate of feed of the cotton to the gins without increases in density of the seed rolls. On the basis of these reports, a 4-80 outfit ginning 30 bales of damp and wet cotton per day before installing drying equipment can gin 37-38 bales in the same length of time and with the same operating cost for labor after installing a drier.

Faster service and monetary benefits from drying should obviously attract an increased volume of business. The ginners of the Southeastern States reported in 1940 that driers were responsible for an average ginning-volume increase of more than 225 bales; those of the Central States, more than 240 bales; and those of the Southwestern States, more than 440 bales.

SUMMARY

Cotton drying at gins is a comparatively recent practice. The first concerted efforts toward development of drying equipment were put forth in the late twenties. Through the early concentration by the U. S. Cotton Ginning Laboratory, established by the U. S. Department of Agriculture at Stoneville, Mississippi, in 1930, on problems of cotton drying, the Government process of drying and the vertical tower drier were developed. In 1931, there were only, approximately, 15 commercial cotton drying installations in the Cotton Belt. About this time manufacturers of gin machinery began to make factory-built designs of the tower driers and to develop other types. So much interest in drying was shown by ginners that by 1935 the number of commercial installations had increased to 200; and each succeeding year drier installations increased at a rapid rate until in 1940 there were 1,340 gins so equipped.

Table 12.--Average increase in ginning capacity as a result of drying, seasons 1938-40

Region	Crop year	Increase in ginning capacity for specified moisture condition: Green, damp, or wet bales	Increase in ginning capacity for specified moisture condition: Dry bales
		Percent	Percent
Southeastern	1938	30	8
	1939	32	7
	1940	25	4
Central	1938	24	3
	1939	22	6
	1940	22	4
Southwestern	1938	23	4
	1939	24	4
	1940	23	4
All	1938	25	4
	1939	26	5
	1940	23	4

Data based on survey by Agricultural Marketing Service, of cotton gins equipped with cotton driers.

When 800 driers were in use, drying as a factor affecting the quality and value of the American cotton crop definitely assumed importance. In 1938--the year that the million bale mark in drying was reached--the U. S. Cotton Ginning Laboratory intensified its efforts to follow up laboratory developments in the field and launched a 3-year survey designed to provide comprehensive information on drier operating practices, benefits, and costs. During the 3 years, operators of cotton driers furnished the information desired, and this was supplemented by field inspections to ascertain causes for problems called to the attention of the laboratory in connection with operating practices and their effects on drying results.

The study revealed that, of the 1,340 drier-equipped gins in the United States in 1940, over one-half were located in the Mississippi Valley States where the moisture problem is very acute and where the ginning volume is higher and the gins are more modern than in some of the older sections of the Cotton Belt. The drier-equipped gins of that State represent 20 percent of the total number of gins in this area. In the Southeastern States, where excess moisture in cotton is also a problem in ginning, only 6 percent of the gins were equipped with driers in 1940. In the Southwestern States, 10 percent of the gins were so equipped that year. More than one-half of the California gins operated driers in 1940.

In 1938, 8.4 percent of the United States cotton crop, or 1 million bales, were handled by driers. This increased to 11.5 percent, or 1.4 million bales, in 1939, and to 14.2, or 1.8 million bales, in 1940. The 3-year average was 1.4 million bales.

For the Cotton Belt as a whole, the proportion of the dried ginnings at drier-equipped gins was about the same for 1938 and 1939, or about 60 percent, but it increased to 67 percent in 1940. The rainfall during the harvesting season in the Southwestern States during each of the 3 years 1938-40 was substantially less than that which prevailed in the other areas. As would be expected, the relative volume of the cotton dried in drier-equipped gins in those States was correspondingly less, being over two-fifths of the cotton receipts for the Southwest as compared with about three-fourths for the other regions.

The average proportion of green, damp, or wet bales in the crops artificially dried by all the drier-equipped gins increased from 31 percent in 1938 to 35 percent in 1939 and 45 percent in 1940. The percentage of dry bales conditioned each year and the percentage passed through driers for cleaning showed only a slight decrease.

For all States, the average drying air temperature used on damp or wet cotton was 192° F. in 1938, 185° in 1939, and 198° in 1940; and on dry cotton, 153°, 147°, and 154° for the 3 years respectively. The percentage of driers operating at temperatures above 200° F. in drying wet cotton was 23 in 1938, 19 in 1939, and 28 in 1940, and those operating above 175° on dry cotton were 20, 13, and 20 for 1938, 1939, and 1940, respectively. These figures show that the drier temperature employed was influenced by the degree of dampness of the cotton, being lower in 1939 when rainfall during the harvesting season was less than that during the season of 1940; and they show also that, although many ginners operated in safe temperature ranges, others exceeded the limit established for staple length preservation. Tests have indicated that with most driers the drying-air temperature should not exceed 160° F. for the usual run of green and damp cotton. A slightly higher temperature can be used with very wet cotton, but under no circumstances should it exceed 200° F. The results of the survey brought out the need for more simple and practical methods for controlling the heat for driers.

Spinning tests on undried and dried cottons have shown that temperatures above 200° F. have resulted in weaker yarns, but that when the recommended temperatures were used in drying, the grade of the cotton was improved without a significant loss in strength of yarn. In tests of undried cotton and cotton dried at temperatures up to and including 190° F., the dried cotton produced yarns that were only 1 percent weaker than those spun from the undried cotton-- a decrease that would be negligible from any practical standpoint in the processing of cotton. The benefits from drying were reflected in lower waste removed by the picker and carding machinery, and this difference in waste removal was about as much as the average difference in waste between Middling and Strict Middling cotton.

The principal sources of heat for driers are steam boilers and furnaces. Sixty-five percent of the driers used steam boilers and 31 percent used furnaces as a source of heat in 1940. There appears, however, to be a tendency toward increased use of furnaces, the maintenance of which for the 3 years of the study averaged 13 cents per bale as compared with 16 cents for boilers. The higher the drying temperature and the lower the ginning volume, the greater was the fuel cost. It ranged from 14 cents for temperatures below 160° F. to 16 cents for temperatures exceeding 190° F., and from 10 cents for a ginning volume of 5,000 bales to 18 cents for a volume of less than 100 bales. In 1940, more than one-half of the boilers were fired with coal, and more than three-fourths of the furnaces were heated with gas flames.

Enhancements in bale value resulting from improvements in grade for wet and dry cottons, as established by the ginners under actual operating conditions, definitely show the advantage of artificially drying seed cotton. The average gain in value per bale for the 3 years, as reported by the ginners, was $4.50 on green, damp, or wet cotton as a result of the grade improvements associated with drying and cleaning the cotton, and over $1 on dry cotton as a result of improved grades brought about by cleaning the cotton.

For the 3-year period covered by the study the reports show average ginning capacity increases of 25 percent were effected on moist cotton and 4 percent on dry cotton by handling the seed cotton through the conditioning and drying units. This additional one-fourth capacity was accomplished because of fewer chokages and breakdowns, which resulted from drying damp or wet seed cotton, as well as by increased rate of feed of the cotton to the gins.

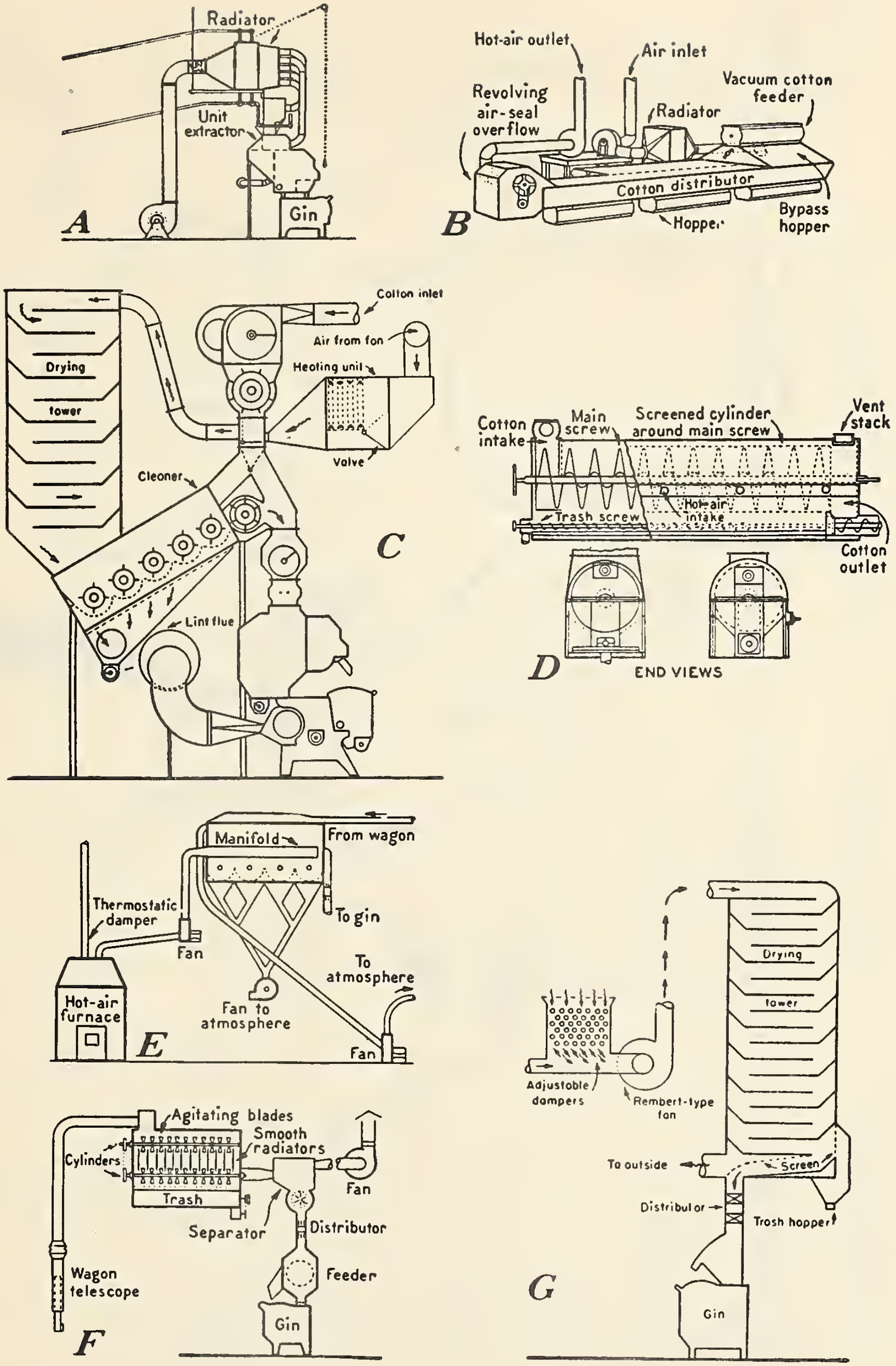
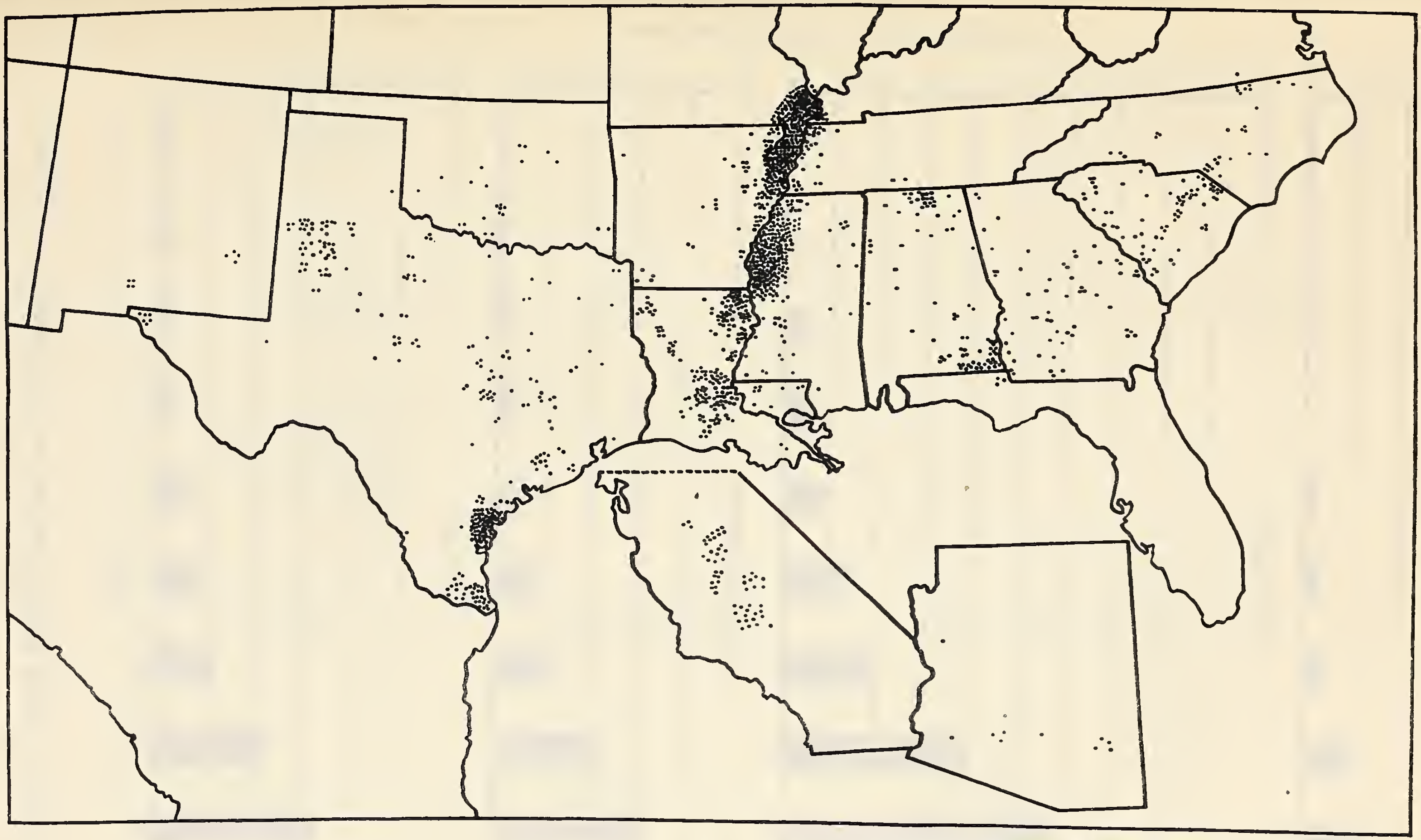


FIGURE 1.- Several designs of commercial driers now on the market: A, Unit extractor-cleaner-feeder system; B, multiple conveyor-distributor drier; C, vertical tower and spiked-drum cleaner-drier; D, ribbon-conveyor cleaner-drier; E, paddle-wheel-drum cleaner-drier; F, multiple-cylinder axial-flow air-line drier; and G, vertical tower drier.



U.S. COTTON GINNING LABORATORIES, STONEVILLE, MISS

FIGURE 2. - Location of cotton gins equipped with cotton driers, United States, season 1940-41.

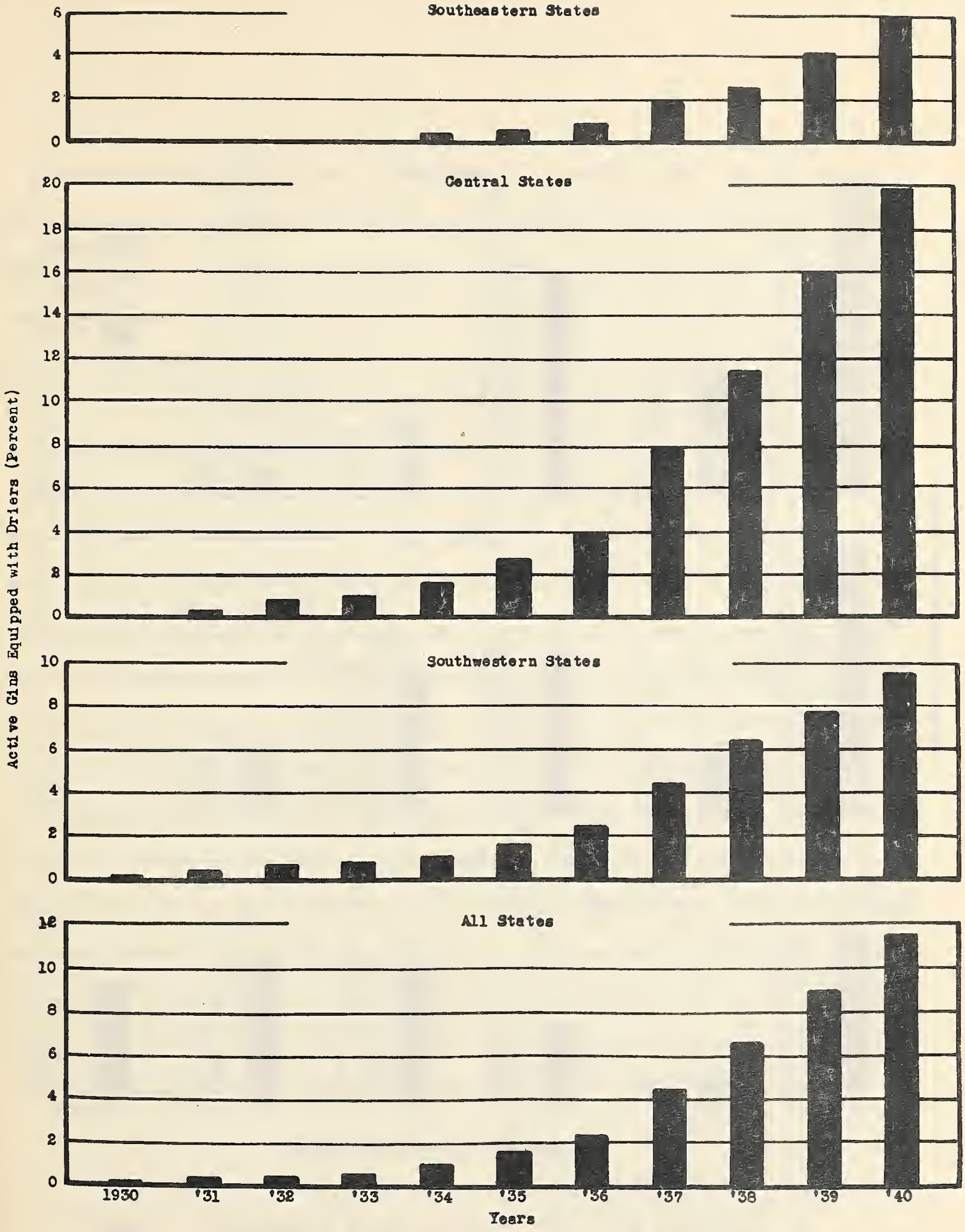


FIGURE 3. - Percentage of drier-equipped gins, by years, 1930-40.

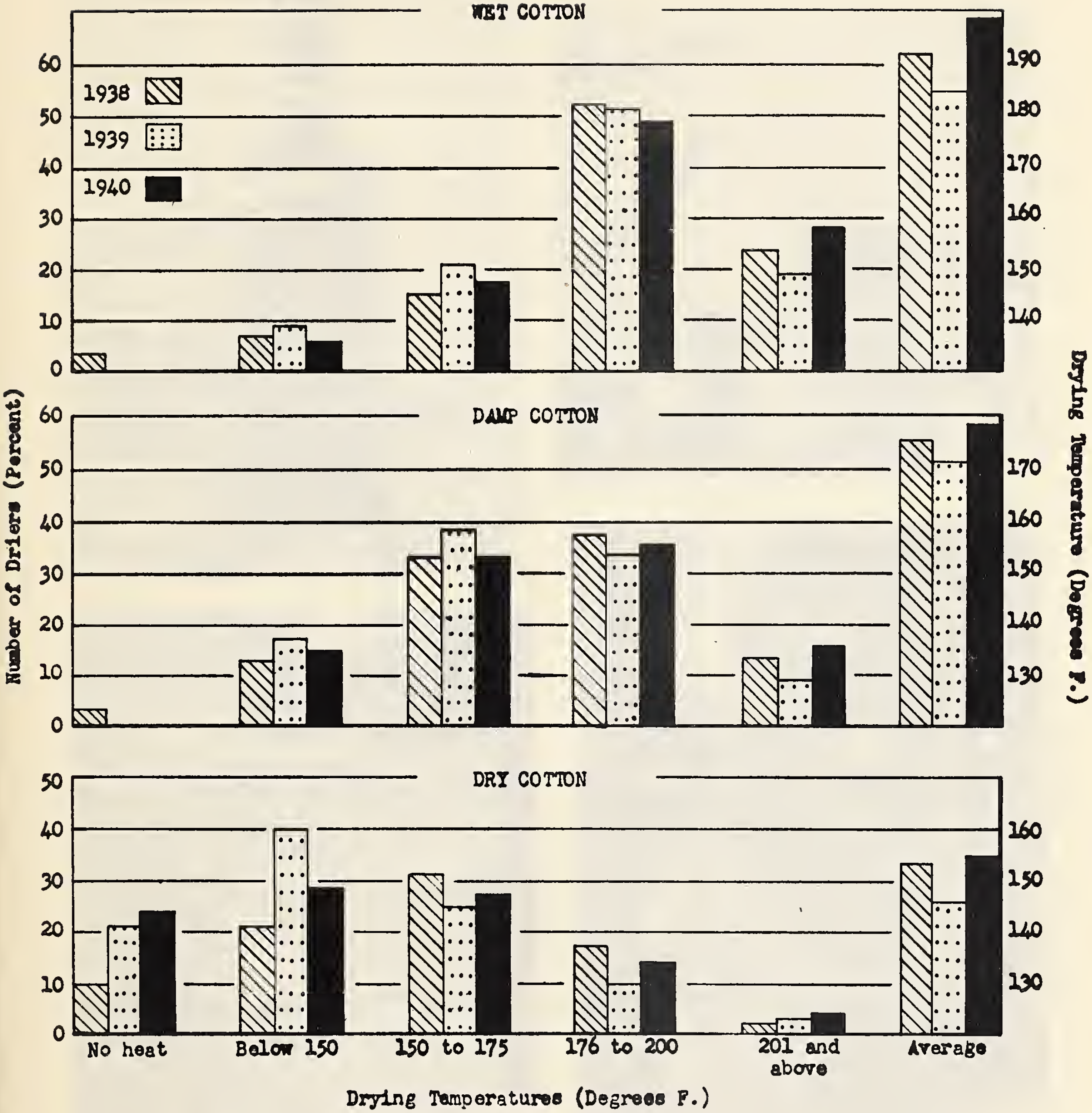


FIGURE 4. - Percentage of driers operating in specified temperature ranges and average drying temperatures used, by years, 1938-40.

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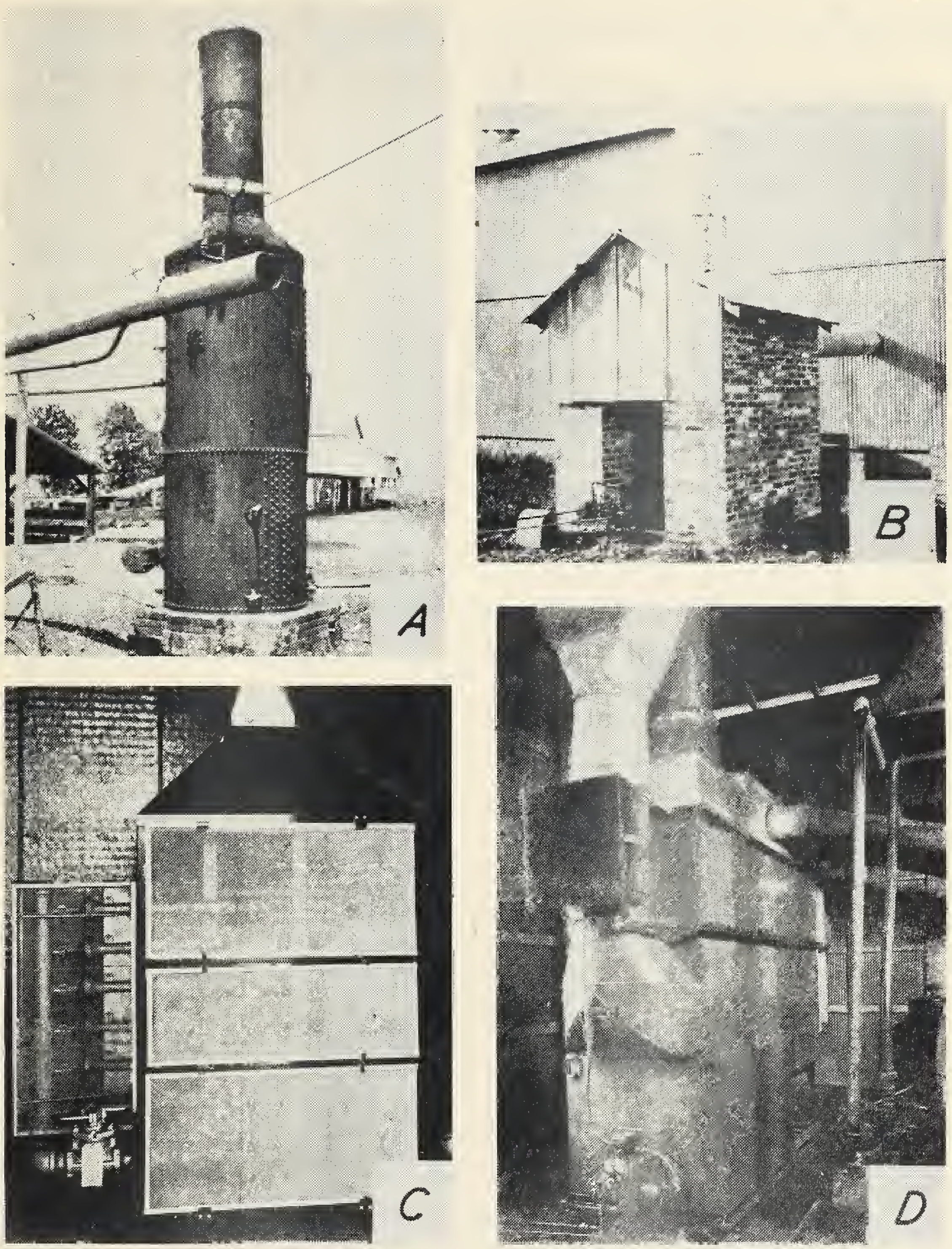

FIGURE 5. - Sources of heat: A, steam boiler; B, oil-burning furnace; C, gas-fired furnace; and D, waste heat recovery unit.

FIGURE 6. - Relationship of fuel cost for operation of cotton drier to volume of cotton dried, seasons 1938-40.